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CRUDE-OIL RECOVERY PROCESS (CORP)

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11 May 77

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Abstract

The Crude-Oil Recovery Process (CORP) is a self-contained, closed-loop, remote-controlled, and superport compatible system that eliminates human in-tank "mucking". CORP recycles inert cleaner, facilitating system safety and recovery of otherwise lost crude-oil and cleaning material.

Introduction

In 1972 the New York Times News Service reported in a copyrighted article that 22 oil tankers totalling 328,336 tons were lost, "the worst for peacetime ship losses since 1891, when accurate ship casualty statistics were first kept" according to Lloyds Register of Shipping. Since the U.S. tanker, V.A. Fogg, exploded and sank (killing its 39-man crew) in February of 1972, tank disasters appear to be accelerating. After the Grand Zenith was lost on January 8, 1977, with its 38-man crew and 8.2 million gallons of fuel oil, the Senate began a major investigation into tanker operations. This was the tenth tanker accident in U.S. waters during only a 3-week period ending January 9, 1977. According to a UPI release, 1976 was the "worst year in history" for such accidents (14).

Circumstances surrounding these losses indicate the need for a safe, universal yet economical technique with which to effectively void, inert, ventilate, clean and reload tanks. CORP combines material, equipment, facilities, personnel and procedures in a cost-effective system to meet this need. No new equipment designs or discoveries are required. CORP may use a single waterless, inerting/cleaning agent in a continuous-stream, closed-loop, non-polluting activity in a practical, modular, integrated, single-point-mooring configuration that is superport compatible.

In addition to reducing hazard levels from toxicity, explosion, fire and asphyxiation, CORP should reduce the costly tanker-downtime experienced when ships are forced to loiter vulnerably without any productivity, while they attempt to dump and flush oily liquid and vapor waste. Under present conditions, at best, these ships use separate inerting and cleaning materials with another costly intermediate period for ventilation and gas-free certification. CORP is keyed toward zero discharge with anticipated recovery of the common inerting/cleaning agent, crude-oil residuals and tank-bottom clingage, with attention to the annual seaward loss of approximately 12 million tons of oily waste along the Texas Gulf Coast alone (9).

As cargo tanks increase in size and complexity, the limits of human ability to perceive, process and react to the dangers involved in tank operations are approached. Current procedures, although varying greatly from port to port and between operators, require that human muckers clean large theoretically inerted and ventilated tanks. In a number of reported cases, the tanks were not sufficiently inert and/or ventilated, resulting in the many catastrophic losses of life, limb, and property. A significant feature of the proposed system relates to transferring the human component ("mucker") from unsafe in-tank manual functions to non-hazardous supervisory and maintenance activities, thereby enriching his job and extending life expectancy.

Although CORP appears to be ocean-going crude-oil tanker oriented only, it is also applicable to other oil tanks, even stationary ones, and may also be applicable to certain other hazardous cargos. Preliminary tests proved both the cleaning and inerting ability of the proposed agent (7).

If national or international energy and/or environmental goals are to be accomplished soon, CORP or some system like it will have to be adopted by the various tank-using industries, service companies, and legislative, judiciary and enforcement bodies. A simplified input/output model of CORP is shown in Figure 1.

*This paper is based on original research begun while the author was on leave from Texas Instruments to Texas A&M University as Principal Investigator/Research Associate and is partially covered by prior copyright. The opinions and conclusions expressed herein are those of the author and not necessarily those of either the U.S. Army, Texas A&M University, or Texas Instruments, Inc.

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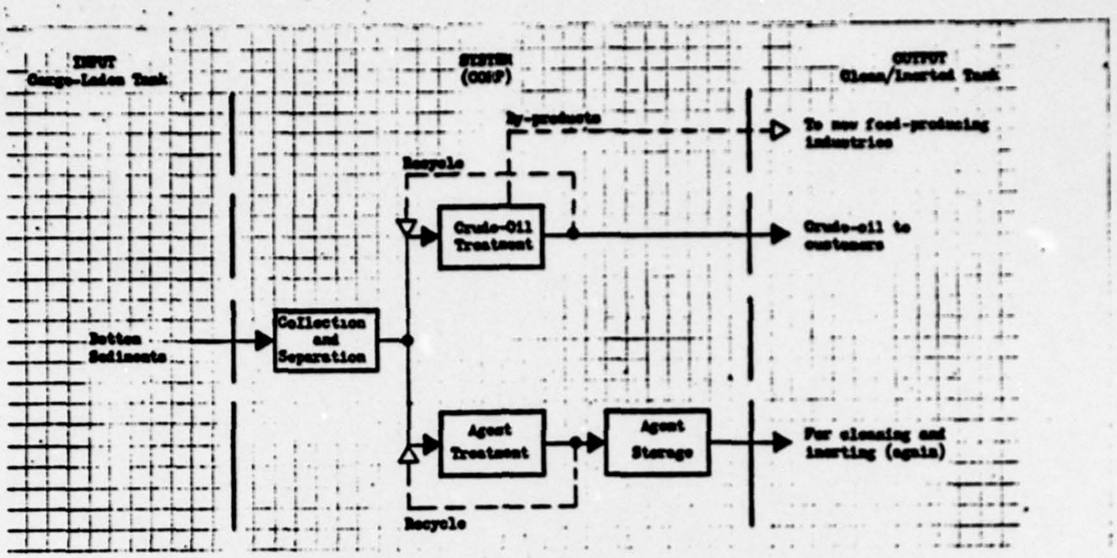


Figure 1. CORP Input/Output Model

Current Tank Cleaning Problems

Too much oil is wastefully lost during tanker operations. Conservation is now a major element of the U.S. National Plan for Energy. In a release dated 19 April 1976, ERDA Administrator Dr. R. C. Seamans, Jr. stated "Each barrel saved means one barrel not imported." He went on to say, "Conservation also will help provide time for the Nation to develop, as it must, new energy sources ..." (19).

Through a literature review and personal contacts with recognized authorities in this field it was confirmed that many techniques and procedures exist for controlling hazards from fire, explosion and toxicity (2, 3, 4, 5, 6). Because more lives and equipment are lost from fire and explosion, more controls have been developed and instituted for these problems while toxicity and the physical hazards have generally been given less attention.

Typical 10-Step Tank Cleaning Task Sequence

Current tank operations involve too many handling steps, between cargo-1 discharge and cargo-2 intake (17). The following sequence of tasks is typical, but not all inclusive (15):

1. Selection, training and indoctrination of the crew, and inspection and calibration of equipment.

2. Preliminary preparations, including external inspection of the tank and a survey of the immediate area.

3. Controlling sources of ignition including static potentials.

4. Isolating the tank from piping sources of flammable liquid or vapor.

5. Voiding or removal (transfer) of cargo-1 to another facility, typically shore-side storage.

6. Inerting the tank by one of the many techniques.

7. Ventilating or gas-freeing the tank to remove inerts and refresh with dry, breathable air.

8. Manually monitoring the air; testing the tank for flammables, explosives, toxicants, corrosives (electrolytes), asphyxiants and oxygen.

9. Certifying that the tank is safe for human entry by a licensed chemist.

10. Allowing human entry for inspection, cleaning, and maintenance operations such as for removal and disposal of sludge and scale, safe storage, loading a higher-quality cargo, or hot work such as welding.

The monitoring, discussed in Step 8, should occur automatically, at many three-dimensional grid points throughout the tank and continuously throughout the procedure although this is not yet being done universally today. Some organizations provide their muckers with "local" (individual) equipment. Without continuous multi-point monitoring--upon reintroduction of air (O_2)--mixing, heating, and oxidation can occur in an uncontrolled manner. The sludge that was relatively dormant when the chemist certified tank safety during Step 9 may evolve contaminants that may

combine with the oxygen and become highly unstable during Step 10. In Steps 6 and 7, useful and expensive inert vapors may become air pollutants (1, 8). Each of the above steps carries an associated level of risk (20, 21).

Four Major Functions

The ten steps of tanker cleaning can be divided into four major functions; voiding, inerting, gas freeing, and cleaning.

The first function, voiding, is that portion of the operation during which cargo is removed. It is during this function that certain waterless techniques are being experimented with to lift the persistent ends of crude-oil cargos.

The second function, inerting, is that operation during which an inert material, generally gaseous, is pumped into the tank to reduce flammability while allowing dilution of the residual cargo vapor as the two are expelled with reduced hazard into the air and/or water environments. In some sophisticated operations, voiding and inerting are combined into a single step known as purging. The latter is much safer and is somewhat more complex than the individual steps of voiding or inerting. It includes voiding, but prior to the entry of oxygen-rich air, entails an intervening slug of inert material that precludes the possibility of dilution. Thus, purging prevents the hazards normally associated with cargo removal from becoming actual risks since without additional oxygen, the liklihood of combusion is nil.

Because of the toxicity associated with most inerting materials and their concommitant oxygen exclusion, the third function, gas-freeing (Step 7 above) must be accomplished to assure habitability (12) before humans can enter the tanks. The difficulty of this step is directly related to weight and air-miscibility of the particular inert material. Heavier inerts tend to collect in hard-to-reach tank bottoms and crevices, just like the cargo residuals, making hazardous pockets wherein non-blown air ventilation is an impossible feat. Similarly, if not particularly miscible in air, the inerts will not be picked up and moved by mere convection. In some cases, special space-consuming and expensive machines are employed to generate the inerting agent onboard. Pumps are then used to coax these inerts out of the tanks (without attention to recovery). Besides losing the value of the inerts that might otherwise be recyclable, most processes allow dissemination of these contaminants within the surrounding natural air and water environments.

The fourth or final function is cleaning, also known as mucking. The literature indicates that neither has there been an attempt to combine the functions of inerting and cleaning, nor has any agent been identified with this ability. Once it is felt that the inert and residual cargo vapors have been removed and replaced sufficiently by clean air, manual cleaning begins. Cleaning is currently achieved to varying degrees of success by using additional hardware, substances, and personnel in the tanks, in direct contact with the existing sludge and inerting agent (18).

Waterless Cleaning

During the last decade, especially, it has been the corporate desire of almost every crude-oil shipping and using entity to eliminate the use of water for tank cleaning. Besides work here in the U.S., waterless cleaning techniques and/or machinery, have typically been tested abroad by the Germans, the Israelis, and the Dutch. At least two U.S. corporations, Shell Oil and Exxon, are involved. Project WOTCAT by Exxon (11), circulated the cargo itself to remove clingage. In this project, lighter hydrocarbons such as naptha would be sprayed through standard nozzles to rinse the tanks while they were still overrich (above the UEL). With the polishing technique described by McKenzie, a tank is filled with kerosene for a given period to lift persistent oil residues.

Objectives

The proposed system, CORP, has three key objectives, namely: 1) to reduce U.S. dependance upon foreign crude-oil; 2) to maintain U.S. sufficiency in spite of increasing domestic demands; 3) to protect existing U.S. resources (not only our energy sources but the cleanliness of our air and water).

To solve the above noted problems and not introduce new costs that would render the technique economically prohibitive, the major objective must be to improve overall cost effectiveness of the entire crude-oil delivery operation from the well-head to the customer.

Existing procedures were analyzed in depth and ten additional objectives became evident and possible, as follows:

1. Reduce cost of raw crude
   a. Reduce oily-waste pollution (crude-oil clingage and cleaning material)
   b. Reduce oily-waste clean-up requirements (legislation, litigation, enforcement and the actual procedures involved, even monitoring).

2. Reduce insurance costs (reduce hazards, improve track record)

3. Reduce tankship turn-around/cycle time (unload, vent/loiter, clean, load)

4. Reduce tank/tanker maintenance costs
   a. Improve accessibility
   b. Reduce sludge build-up
   c. Reduce corrosion

5. Increase tankship per-voyage yield
   a. Reduce slop-tank requirements
   b. Liberate other spaces for tank capacity

6. Reduce cost of labor (port and ship crew)
   a. Reduce personnel turnover (fatigue/dissatisfaction)
   b. Improve mucker function (job enrichment)
   c. Improve mucker life expectancy (sickness/mortality)

7. Increase port real estate yield (systematic use and enhancement of collocated systems safety)

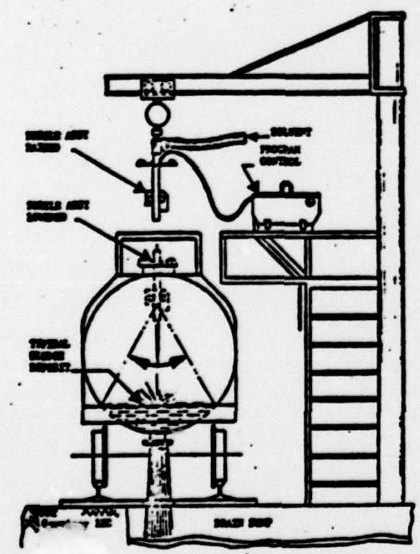
8. Capture, recycle, and reuse agents (inerting and/or cleaning)

9. Recapture oily-wastes for other economic processes (single-cell proteins)
   a. Develop new industry
   b. Develop new by-products

10. Improve system flexibility/compatibility
   a. Superport
   b. Shore-based/land-based
   c. Mobile service facility.

<u>Details of CORP, the Proposed System</u>

From all indications, the proposed system is capable of satisfying and/or supporting <u>all</u> of the 10 objectives noted above. CORP is a system developed around existing hardware and software (see Figure 2). This system is based upon injection of the cleaning/inerting agent as cargo voiding begins. The process of inerting continues until the tank is empty of its first cargo. Since the same material is used for cleaning, it is obvious that cleaning--to some degree--has already been completed during voiding. The latter is partially responsible for the reduction in cleaning time, as such.



Figur[illegible] [illegible]cal Tank Car Open-Loop Type ([illegible] [illegible]figuration in Use Today

Once the tank is cleaned, it is ready to receive its next (second) cargo. Since the tank is not allowed to exchange air with the environment, the only air allowed into the tank is controlled and is only to maintain atmospheric equilibrium. When the next (second) cargo is ready to be added (no matter how much later or how far away), this controlled amount of air is drawn off in exchange.

Notice that the tank is kept inert by the cleaning agent, which is non-toxic and non-corrosive, for the entire period between removal of cargo-1 and addition of cargo-2.

Rather than operating above the UEL, this system will maintain the vapor space below the LEL upon initiation of the voiding process. Thus, the problem of how to safely get below the LEL from an overrich condition, as exists with most other techniques, will be eliminated. It is believed that several major benefits will accrue from acceptance of this waterless Crude-Oil Recovery Process.

The system may provide hardware, procedures, and a vehicle for greater cooperation among and more clearly defined responsibilities for ship owners, shippers, port operators/authorities, and tanker-fleet operators. This system is ideally suited to current instrumentation techniques and may further improve visibility and the ability to comply with local, state, federal and international pollution abatement recommendations, regulations, and goals. This system is expected to reduce human, equipment, and facilities hazards from fire and explosion while emptying, inerting, cleaning or filling tanks. The system will eliminate the cargo loss that currently becomes air and water pollution, caused by dumping the cleaning-agent/oily-waste overboard. The proposed system is expected to reduce the logistics burden and down time by combining inerting and cleaning into one operation with a single material.* This should be accomplished without the usual intervening 2-day ventilation requirement since no human entry into the tank is necessary for tank cleaning. This may further reduce costs by eliminating the need for many of the respiratory protective devices (16).

The automated nature of the proposed system may provide the sea-duty crew an ideal chance for shoreside R&R while the ship is being serviced thus providing simultaneous in-port maintenance for the ship and crew alike--a feature never previously available short of a full-fledged dry dock. It is not intended for the level of automation to reduce personnel, but--instead--to transfer functions such that the crew's longevity and growth potential is improved. Finally, the proposed system should reclaim approximately 100 percent of both the common inerting/cleaning agent and the residual cargo.

*The proposed inerting solvent is available worldwide and is typically manufactured in the U.S. by DuPont, Union Carbide and Baron-Blakeslee.

CORP should be capable of use with existing tankers with an improvement in cargo, fuel and/or ballast carrying capacity. This should be accomplished by reducing the need for on-board tank-washing slop tanks and separator systems, and eliminating on-board inert-gas generators and their attendant manifolding, maintenance, and power requirements. A simplified schematic of the proposed system is shown in Figure 3.

The system should be impervious to degradation from the toxicity or hazardous nature of the cargo (the system should be inerting rather than complicating in nature). It is planned that the system be in compliance with the Guide for the Disposal of Shipboard Wastes (13), Federal regulations and the International Conference on Pollution (10).

Another key attribute is that CORP should be able to work in parallel with solid-waste disposal systems and other portside functions without shipboard or shoreside interference, or new on-board power requirements.

Finally, this proposed tank inerting and cleaning system combines three additional crucial propositions: 1) the use of a non-contaminating, non-corrosive closed-loop or continuous stream; 2) the ability to use the entire procedure at a flexible single-point mooring; and 3) reduced demand for depot (dry dock) activities.

Synopsis of Completed Testing

One set of preliminary tests proved that the proposed cleaning agent is able to lift crude-oil from various tank surfaces under STP ambient conditions (7). Additional Pensky-Martens tests validated the theory that the proposed inerting-agent/crude-oil mixture flash-points are considerably higher than that of crude-oil alone (Figure 4). These two sets of tests substantiate the value of a common inerting/cleaning agent as proposed with CORP.

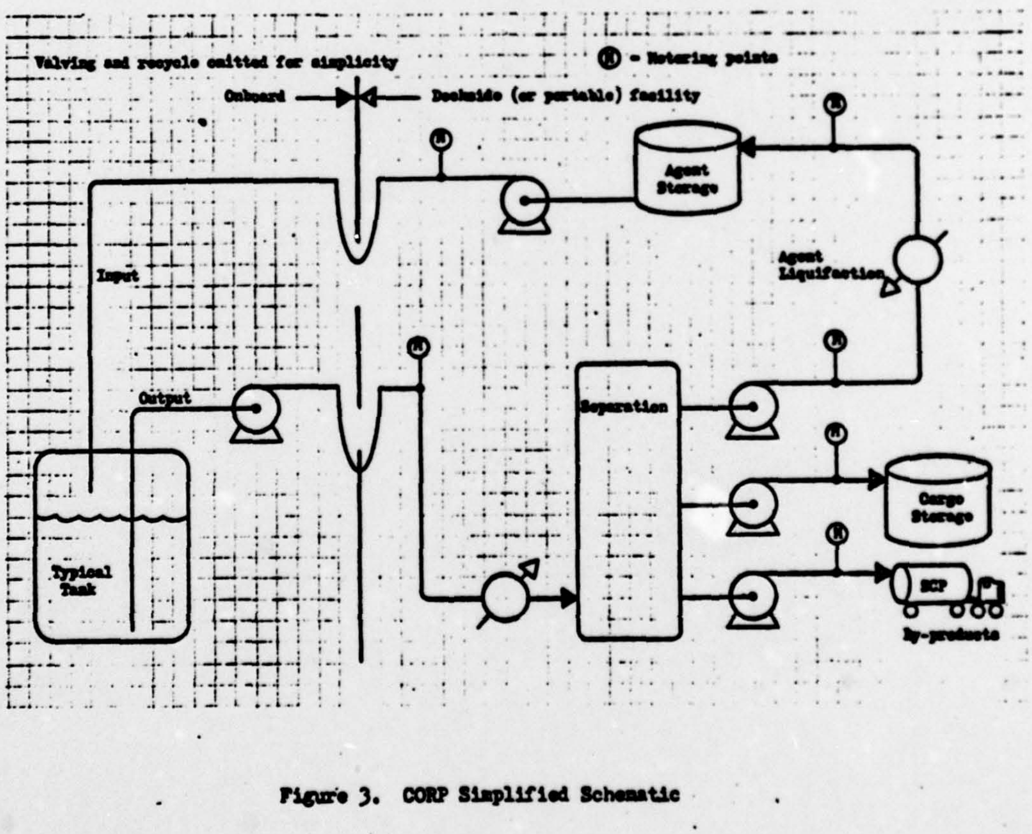


Figure 3. CORP Simplified Schematic

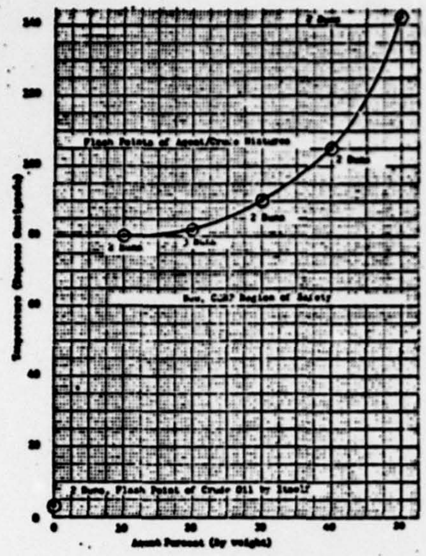


Figure 4. Comparison Between the Flash Points of Crude-Oil Alone and Agent/Crude Mixtures by Pensky-Martens Closed-Cup Tests

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A more definitive treatment of the CORP principle may be found in "Crude-Oil Losses and Pollution, Tanker Inerting and Cleaning, Human Safety, and Fluoro-Solvents", May 1975.

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